

National Aeronautics and
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Mars Science Laboratory

NASA is developing a 2009 Mars mission to set down a sophisticated, large, mobile laboratory using a precision landing that will make many of Mars' most intriguing regions viable destinations for the first time. Once on the ground, the Mars Science Laboratory would analyze dozens of samples scooped from the soil and cored from rocks as it explores with greater range than any previous Mars rover.

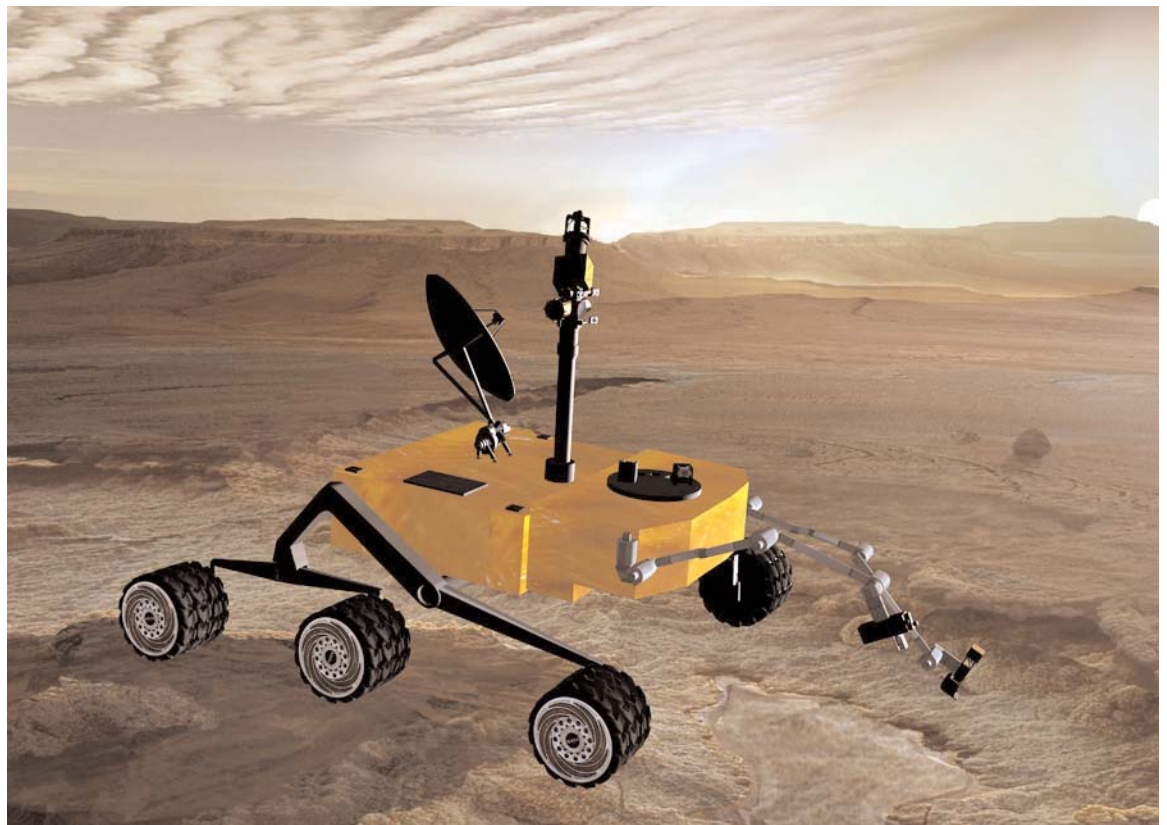
As planned, the robotic laboratory will carry the most advanced payload of scientific gear ever used on Mars' surface, a

payload more than 10 times as massive as those of earlier Mars rovers. Its mission: investigate the past or present ability of Mars to sustain life.

Mission Overview

Plans for the Mars Science Laboratory call for launch from Cape Canaveral Air Force Station, Florida, in September or October 2009 and arrival at Mars in summer 2010.

The spacecraft is being designed to steer itself during descent through Mars' atmosphere with a series of S-curve maneuvers similar to those used by astronauts pilot-



ing NASA space shuttles. During the 3 minutes before touchdown the spacecraft would slow its descent with a parachute, then use retro rockets mounted around the rim of an upper stage for the final 500 meters (1,640 feet) of the descent. In the final seconds, the hovering upper stage would act as a sky crane, lowering the upright rover on a tether to the surface.

As envisioned, the mobile laboratory itself will be more than twice as long (about 2.2 meters or 7 feet) and four times as heavy as NASA's twin Mars Exploration Rovers launched in 2003. It would inherit some design elements from them, including six-wheel drive, a rocker-bogie suspension system and cameras mounted on a mast to help the mission's Earthbound humans select exploration targets and driving routes. Unlike earlier rovers, Mars Science Laboratory is being designed to carry equipment to gather samples of rocks and soil, crush them and distribute them to onboard test chambers inside analytical instruments.

NASA's Jet Propulsion Laboratory, Pasadena, Calif., builder of the Mars Science Laboratory, is engineering the rover to roll over obstacles up to 65 centimeters (25 inches) high and to travel up to about 200 meters (660 feet) per day on martian terrain.

NASA is considering nuclear energy for powering the Mars Science Laboratory. The rover would carry a U.S. Department of Energy radioisotope power supply that would generate electricity from the heat of plutonium's radioactive decay. This type of power supply could give the mission an operating lifespan on Mars' surface of a full Mars year (687 Earth days) or more. NASA is also considering solar power alternatives that could meet the mission's science and mobility objectives.

The mission is being designed to use radio relays via Mars orbiters as the principal means of communication between the Mars Science Laboratory and Earth.

Research objectives

The overarching science goal of the mission is to assess whether the landing area ever had or still has environmental conditions favorable to microbial life.

The investigations to support that assessment include:

- ☐ Detecting and identifying any organic carbon compounds.
- ☐ Making an inventory of the key building blocks of life.
- ☐ Identifying features that may represent effects of biological processes.
- ☐ Examining rocks and soils at and near the surface to interpret the processes that formed and modified them.
- ☐ Assessing how Mars' atmosphere has changed over billions of years.
- ☐ Determining current distribution and cycles of water and carbon dioxide, whether frozen, liquid or gaseous.

NASA will identify a Mars Science Laboratory landing site with characteristics believed to make it among the most likely sites on the planet to have retained clues to the presence of liquid water, a condition favorable to life. The site will also need to meet criteria making it suitable for a safe landing.

Selection of a landing site of prime scientific interest will benefit from examining candidate sites with NASA's Mars Reconnaissance Orbiter beginning in 2006, from earlier orbiters' observations, and from a planned capability of landing within a target area only about 20 kilometers (12 miles) long. That precision, about a five-fold improvement on earlier Mars landings, will make feasible sites that would otherwise be excluded for encompassing nearby unsuitable terrain. For example, the mission could go to the floor of a small crater or wide canyon whose

steep walls would make a less precise landing too risky.

Mission plans also call for the capability of landing at much higher altitudes and latitudes than earlier Mars rovers. That gives the advantage of making about three-fourths of Mars' surface accessible, more than 10 times as much as considered accessible for the Mars Exploration Rover Project.

Advancing the technologies for precision landing of a heavy payload will yield research benefits beyond the returns from Mars Science Laboratory itself. Those same capabilities would be important for later missions both to pick up rocks on Mars and bring them back to Earth and conduct extensive surface exploration for martian life.

Science Payload

In April 2004, NASA solicited proposals for specific instruments and investigations to be carried by Mars Science Laboratory. The agency selected eight of the proposals later that year and also reached agreements with Russia and Spain for carrying instruments those nations will provide.

A suite of instruments named Sample Analysis at Mars would analyze samples of material collected and delivered by the rover's arm. It includes a gas chromatograph, a mass spectrometer and a tunable laser spectrometer with combined capabilities to identify a wide range of organic (carbon-containing) compounds and determine the ratios of different isotopes of key elements. Isotope ratios are clues to understanding the history of Mars' atmosphere and water. The principal investigator is Dr. Paul Mahaffy of NASA's Goddard Space Flight Center, Greenbelt, Md.

An X-ray diffraction and fluorescence instrument called CheMin would also examine samples gathered by the robotic arm. It is designed to identify and quantify the minerals in rocks and soils. The principal investigator is Dr. David Blake of

NASA's Ames Research Center, Moffett Field, Calif.

Mounted on the arm, the Mars Hand Lens Imager would take extreme close-up pictures of rocks, soil and, if present, ice, revealing details smaller than the width of a human hair. It will also be able to focus on hard-to-reach objects more than an arm's length away. The principal investigator is Dr. Kenneth Edgett of Malin Space Science Systems, San Diego, Calif.

Also on the arm, the Alpha Particle X-ray Spectrometer for Mars Science Laboratory would determine the relative abundances in different elements in rocks and soils. Dr. Ralf Gellert of Max Planck Institute for Chemistry, Mainz, Germany, is principal investigator for this instrument, which will be provided by the Canadian Space Agency.

The Mars Science Laboratory Mast Camera, mounted at about human-eye height, would image the rover's surroundings in high-resolution stereo and color, with a zoom-telephoto lens and the capability to take and store high-definition video sequences. It would also be used for viewing materials collected or treated by the arm. The principal investigator is Dr. Michael Malin of Malin Space Science Systems.

An instrument named ChemCam would use laser pulses to vaporize thin layers of material from martian rocks or soil targets up to 10 meters (33 feet) away. It will include both a spectrometer to identify the types of atoms excited by the beam and a telescope to capture detailed images of the area illuminated by the beam. The laser and telescope sit on the rover's mast and would share with the Mast Camera the role of informing researchers' choices about which objects in the area make the best targets for approaching to examine with other instruments. Dr. Roger Wiens of Los Alamos National Laboratory, Los Alamos, N.M., is the principal investigator.

The rover's Radiation Assessment Detector would characterize the radiation

environment at the surface of Mars. This information is necessary for planning human exploration of Mars and relevant to assessing the planet's ability to harbor life. The principal investigator is Dr. Donald Hassler of Southwest Research Institute, Boulder, Colo.

The Mars Descent Imager would finish its job in the seconds before landing, capturing color high-definition video of the landing region during the descent to provide geological context for the investigations on the ground and aiding precise determination of the landing site. Dr. Michael Malin is principal investigator.

Spain's Ministry of Education and Science is providing the Rover Environmental Monitoring Station to measure atmospheric pressure, temperature, humidity, winds, plus ultraviolet radiation levels. The principal investigator is Dr. Luis Vázquez of the Center for Astrobiology, Madrid, an international partner of the NASA Astrobiology Institute. The team for this investigation includes the Finnish Meteorological Institute as a partner.

Russia's Federal Space Agency is providing the Detector of Albedo Neutrons to measure subsurface hydrogen up to one meter (three feet) below the surface.

Detections of hydrogen may indicate the presence of water in the form of ice or bound in minerals. Dr. Igor Mitrofanov of the Space Research Institute, Moscow, is the principal investigator.

In addition to the science payload, equipment of the rover's engineering infrastructure would contribute to scientific observations. Like the Mars Exploration Rovers, Mars Science Laboratory will have a stereo navigation camera on its mast and low-slung, stereo hazard-avoidance cameras. Equipment called the Sample Acquisition/Sample Preparation and Handling System will include the robotic arm with tools to grind off rock coatings, collect core samples of rocks and scoop up soil, plus deck-mounted devices to crush and distribute collected samples.

Program/Project Management

The Mars Science Laboratory is managed for NASA's Science Mission Directorate, Washington, D.C., by JPL, a division of the California Institute of Technology, Pasadena. At NASA Headquarters, Mark Dahl is the Mars Science Laboratory program executive and Dr. Michael Meyer is program scientist. In Pasadena, Richard Cook of JPL is project manager and Dr. Edward Stolper of Caltech is project scientist.